International Journal of Advanced Technology in Engineering and Science
Vol. No.9, Issue No. 05, May 2021
www.ijates.com
ijates
ISSN 2348 - 7550

Innovative Fertilization and Irrigation Monitoring System for Smart Agriculture using IoT

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ABSTRACT

Every year, Indian farmers face risks such as low rainfall, price volatility, and rising debts. But risks from the COVID-19 pandemic are putting new challenges in front of a sector that is already under threat. The lock down created both a shortage of labour and equipment. Implementation of technology such as IoT can help to minimize human labour using automation; provide quick access to remotely monitor through any device and at any region crop and soil health. This paper proposes an innovative system based on the Internet of Things (IoT) to collect and monitor real-time data to determine the need of fertilizer in the soil and automatic irrigation system to automate the Water Management and Crop Monitoring through online automated intimation system using user-friendly Android application on farmer's electronics gadgets aimed to reduce manual labour and optimizing water usage and high yielding ofcrops.

Index Terms – Agriculture, Fertilization, IoT, Irrigation.

I. INTRODUCTION

Agriculture is one among the first occupations of man since the first civilizations. Even today, manual intervention is inevitable. Around sixty to seventy percent of the population depends on the resources from the agricultural sector. This sector is evolving with the arrival of the knowledge and communication technology which is playing its role in bringing the change. Efforts are being made to reinforce productivity and reduce losses by using the state of the art technology and equipment. One such technology like the internet of Things may result in cheap yet effective methods of agriculture, which successively will surely produce to higher quality production. IoT agriculture system applied in fields like Precision farming, livestock monitoring, and greenhouse monitoring[1].

Irrigation, Fertilizers, pesticides, and quality of yield, disease monitoring, and detection are the Key factors of importance for agriculture. Most of the time the expertise are required to research the issues which can be time consuming and costlier issue in developing countries. In other instances, real-time data about soil, air quality, water levels, etc. can help farmers in making a much- informed decision about planting and harvesting crops, thereby increasing the general yield of the crops. IoT and automation intertwine to create a number of the foremost efficient and cost-effective solutions to human problems. Consistent with the Gartner IoT sector alone is predicted to be worth around 457 billion dollars within the present year [2]. IoT technology and automation are efficient thanks to ease in connectivity to a various range of devices, minimizing human labor, quick Access, efficient communication, time efficient, and analytics. Applications of IoT in Agriculture is shown in Fig1.

Determination of need of fertilizer [3] is the key outcome of soil testing forsuccessful plant growth. Due to its complex laboratory procedure soil testing is infrequently done by the farmers [4]. Generally soil testing for the nutrients [5] is administered manually in commercial laboratories that can-not facilitate the farmers due to longer usage and highprices.

Fig. 1 Applications of IoT in Agriculture.

Normally, Soil testing [6] is completed for soil pH, macronutrients like nitrogen (N), phosphorus (P), and potassium (K) and micronutrients test for an additional mineral like lead, calcium, zinc, copper, etc., during a distinct method.

Fig. 2 Corps with insufficientwater.

Fig. 3 Corps with Wastage ofwater

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It is extremely important to cultivate crops for much better yield and quality delivery. In most cases, irrigation is completed through conventional methods of flow from one end to another. Such supplies can leave a variety of moisture levels in the field. Usually, the farmer pumps the water more or less to cultivate the land. This might end in wastage of water or insufficiency to the crops shown in Fig 2 and Fig 3. The administration of the water system are often enhanced by utilizing a programmed watering framework to scale back manual labor and optimizing water usage increasing the productivity of crops[7].

We proposed an innovative system supported the internet of Things (IoT) to gather and monitor real-time data to work out the necessity of fertilizer in soil and recommendation with the aid of an NPK sensor and fuzzy algorithm, to automate the Water Management and Crop Monitoring through online automated intimation system using user-friendly Android application on farmer's electronics gadgets. This may have been found to be of benefit to farmers for the high yield of crops and the saving of waterresources.

II. LITERATURE REVIEW

Substantial advancements in the domain of Agriculture automation has been surveyed. The literature survey describes in three different categories.

A. Methods to detect nutrients within the soil

Table I shows the major findings in methods to detection of soil nutrients.

TABLE I

Methods to detect nutrients within the soil

Sr. No.	Authors	Proposed concept and Details
1	Shamshiri, R. et al. [8]	Environmental conditions role in the optimal growth of plants in different setups.
2	Doyle et al. [9]	The existence of microbial biomass C and N in soil extracts in thelaboratory.
3	Yong he et al. [10]	Colorimetric analysis to detect urinary dipsticksin urine samples.
4	Henrikenson &Olsen [11]	The occurrence of nitrite and nitrate in water and soil extract using the colorimetricprinciple.
5	Regalado and Cruz [12]	Soil pH and nutrients levels especially the presence of nitrogen (N), phosphorus (P), and potassium (K) in the soil using the colorimetrical principle with the help of a color sensor.
6	Deepa et al. [13],	The detection of NPK nutrients using the Colorimetric theory with the aid of fibre optic channel for light transmission.
7	Ben-dor and Banin [3]	The infrared analysis to evaluate the soil properties.

B. logic to investigate the soilnutrient

Appropriate logic is needed to investigate the soil nutrient level dependent on the reading of the sting level sensor. As data obtained from the NPK sensor is obscure and unclear, it is difficult to make a decision on soil nutrient levels.

Table II reveals a different logic for investigating soil nutrients.

TABLE II

Logic to investigate the soil nutrient

Sr. No.	Authors	Proposed concept and Details
1	Zakarian [14]	The fuzzy-rule-based reasoning approach integrated with an IDEF3 to the study of the process model to represent vague process variables.
2	Dutu et al. [15]	Study of Fast Fuzzy Modeling formalism using fast modeling approach with the aid of the Selection-Reduction family of methods for RB learning to deal with complex real-world problems.
3	Feng [16]	Carried out a brief survey on analysis and design methods of model based fuzzy control systems. Focused on the so-called T–S models or fuzzy dynamic models.
4	Zulfikar et al. [17]	The degree of membership was determined using Mamdani Fuzzy method and achieved the accuracy of up to 91.4%.
5	Hong and Lee[18]	Proposed a general learning method as a framework for automatically deriving membership functions and fuzzy if-then rules from a set of given training examples.
6	Ganesh Kumar et al. [19]	Improved technique for extracting the fuzzy rule set and tuning the membership function using improved particle swam optimization.

C. Automation in Fertilization and Irrigation

Various works has been carried out in the sector of automation in fertilization and Irrigation listed in Table III.

TABLE III

Automation in Fertilization and Irrigation

Sr. No.	Authors	Proposed concept and Details
1	Lavanya G. et al. [21]	A novel NPK sensor that integrates the colorimetric concept of LDR and LEDs.
2	Bhawarkar, N. et al. [22]	Automation of irrigation systemshasbeen implementedthrough different controllers like microcontroller 89S52 and relay, PIC controller, ARM controller and also using PLC & SCADA.
3	Ramana Reddy [23]	The Arduino Moisture Sensor and Wi-Fi Module are used in a configured water system with a set-up setup for the terrains.
4	Keswani, B. et al. [24]	The method of irrigation control uses a structural similarity (SSIM)-based

		water valve management mechanism that is used to identify agricultural regions with water deficiency.
5	Nawandar, N.& Satpute,V. [25]	Irrigation plan, neural net decision-making, and remote data viewing.
6	Bin Ismail et al. [26]	A system to watch the soil moistureand to regulate watercontent through the online browser on the laptop, mobile, and other handheld and compact devices.
7	Katyara,S. et al. [27]	The irrigation system has been developed using WSN. The collected data on the water management system is accessed on the web using cloud computing services.
8	Navarro-Hellín, H. et al. [28]	Architecturefocusedon various wireless nodes with GPRS connectivity.
9	Puranik,V. et al. [29]	The farmers can strategize whichcropsto grow consistent with the market using the GSM Module and pH sensor.
10	Kulbacki et al. [30]	Concentrated on the most commonly used sensors for crop monitoring and processing methods using UAV imaging.
11	Barh, A., & Balakrishnan , M. [31]	Mobile applications can help agriculturedevelopment faster and hustle free.
12	R. Mishra et al. [32]	Proposed system for the reduction of energy waste by observing electrical appliances on the basis of sensors.

Many researchers have worked on the IoT agriculture system and have discussed a range of technological and architectural issues through the implementation and design of various IoT agricultural solutions. In addition, there are also a range of open issues and problems, consistent with the study point of view within the literature. To the simplest of our understanding, while researchers have conducted experiments to measure nutrient levels inside the soil, the majority of the farmers are often unable to understand the test results and therefore the appropriate decision making mechanism needed to farmer during cultivation. Many sorts of sensors were designed for various uses for the performance of chemical properties. These are high-cost CMOS products. A shortcoming of the algorithms applied is modified to urge desire outcome but at the value of accelerating complexity in hardware andsoftware.

Agriculture automation with involving Fertilization and Irrigation together should become more conscious and implement strategies to minimize the burden and supply quick access even from a distant place. There are sorts of mobile applications, utilized over the world for various segments, including farming, but the appliance contains live data monitoring in Fertilization and Irrigation remains is restricted. We proposed a system which combined monitoring of fertilization using appropriate low-cost sensor and automatic irrigation using android application.

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Vol. No.9, Issue No. 05, May 2021
www.ijates.com
ijates
ISSN 2348 - 7550

III. DESIGN OFSYSTEM

Due to the constraints that exist in the traditional methods of soil testing in the laboratory, the farmers should be informed of the start of the cultivation of the soil, The proposed study indicates an IoT system to track nutrients in the soil then alerts the farmer in their The respective farm field on the quantity of fertilizer to be used during the cultivation of land and automate the water management for efficient irrigation. Fig. 4 shows the proposed IoT system that senses the amount of the soil nutrients present within the soil and moisture level within the land. The pump for water flow ON/OFF consistent with the necessity of water within the soil. The events of the suggested IoT system are demonstrated in three phases viz., 1. Selection of sensors, 2. Analysis of soil nutrient and water requirement of soil, 3. Data monitoring system for farmers.

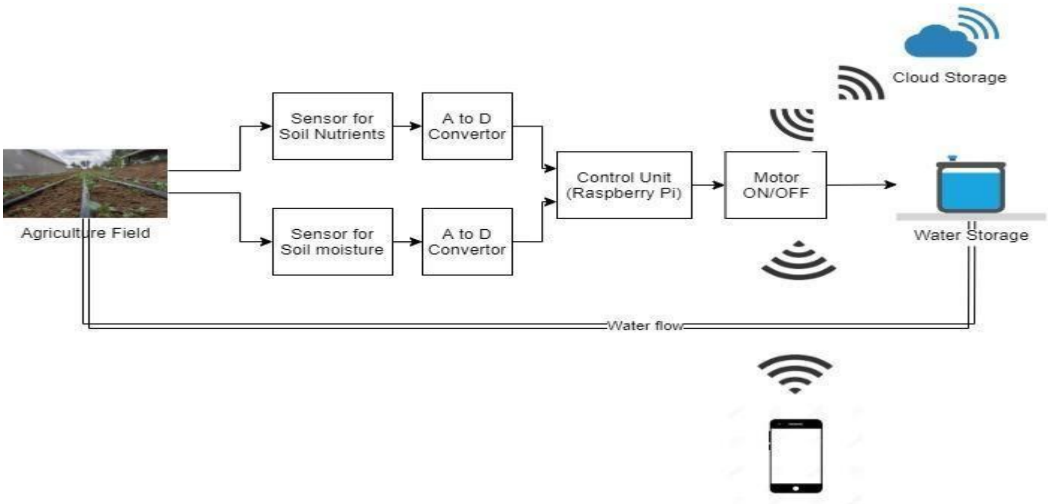

Fig. 4 Block diagram of the proposed system

A. Selection ofsensors

We need 2 types of Sensors one for soil nutrients and another for soil moisture level. The soil nutrients sensor used to measure individual chemical solutions of Nitrogen (N), Phosphorous (P), and Potassium (K). The Soil Moisture Sensor is a sensor connected with a water management system to fix threshold value then response accordingly to a prefix threshold value to irrigate crop field.

B. Data Acquisition and Controlunit

We have chosen raspberry pi for the control unit (CU) because it works as a server is less expensive than a traditional server, Supports Linux, Python open-source community.

The soil nutrient sensor is connected to the CU to perform the analysis of the sensed data and therefore the particular fertilizer information is distributed over the web. The analog value of the sensor is linked to the analog to the digital converter (ADC) Fig. 4 displays the connecting diagram of the sensor to the Raspberry pi via the ADC. The digital processed output of ADC is linked to raspberry pi via WI-FI access for further study of the lack of nutrient content in the soil.

The Soil Moisture Sensor (SMS) can be a sensor connected to the irrigation system controller that measures the soil moisture content. The SMS reads the value of moisture content within the soil the analog value reads by the SMS sensor is connected to ADC. Fig. 4 shows the connection diagram of the SMS sensor with the Raspberry pi through ADC. A threshold value is about at the start depending upon the plant being watered and region during which it's being watered up. The SMS reads the value once within a specified delay time. If the moisture is above the threshold value specified by the user then sensor ceases reading the value and transfers the control to the control unit (Raspberry Pi) which switches on the motor to start out the irrigating of the system.

C. Analysis of soil nutrient and water requirement of soil

Analyzing the nutrients sensor data lead to choosing the quantity of fertilizer to be used prior to planting. This is also a difficult job, as the sensed data from soil solutions are unclear with uncertain boundary between values. In order to deal with the difficulties, the idea of fuzzy logic is used to draw a clear conclusion on the quantity of fertilizers. It's applied using the Mamdani inference procedure that has input NPK sensor with three different nutrients level for (N, P, and K) asoutput.

The SMS is blocked within the soil and water is added to the soil with one inch of standing water on the surface. The soil next to the SMS is kept out of the sun for the whole day, and if it rains during this time the method would like to start over. After the whole day, the value of soil moisture is read as a threshold value. A 20% decrease is often made at the moisture level to allow the water to be soaked longer.

D. Data monitoring system forfarmer

The proposed work aims to make it easier for farmers to use the correct fertilizer to be applied to the soil at the right time and to optimize irrigation using an integrated IoT system. This section describes the accessibility of the IoT framework developed for Androidapplications.

Fuzzy logic rule system embedded in the Raspberry pi, based on that the program executed to determine the appropriate quantity of fertilizer to be used for the soil and water level requirement is executed to link the data to the cloud and send the fertilizer and irrigation live data through the Android application to the farmer. The other part of the built-in software is to connect to the cloud database and sends the readings of the sensor and the responds the fuzzy logic device for futureanalysis.

IV. WORKFLOW CHART

The workflow in fig 5 is a soil fertilizer monitoring system. The first stage of the cycle is the monitoring of soil nutrient levels followed by a fuzzification data analysis and the sending of processed data to the cloud storage network as well as to the farmer's smartphone using the android program.

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ijates
ISSN 2348 - 7550

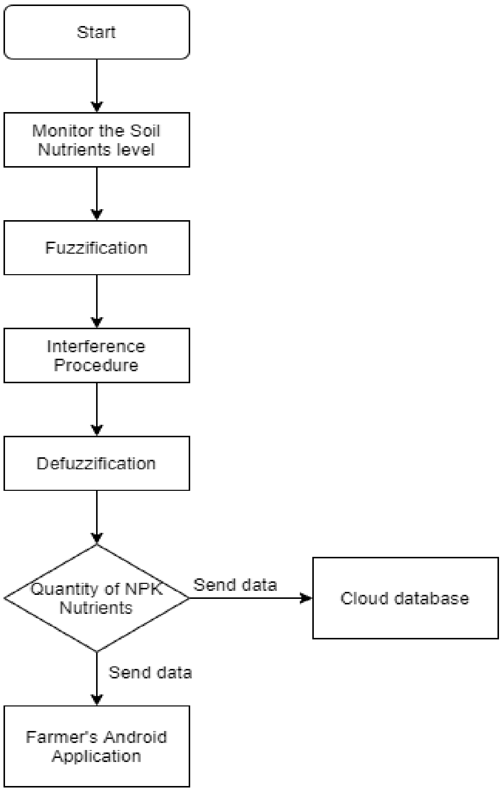

Fig 5 Flow-chart for soil fertilizer Monitoring system

Fig 6 shows the workflows associated with the automatic irrigation system. At the beginning of the procedure, a threshold value is set. Once the threshold value has been acquired, soil moisture Sensors are able to read moisture content at each fixed time interval. The data is obtained and compared to the threshold value. After the comparison, the system has two courses of action:

Case I: If the moisture level is greater than the threshold value.

When the moisture content reads from the soil using SMS and is found to be higher than the threshold value, the value is read and measured again after a fixed time delay. This process is continued until Case II.

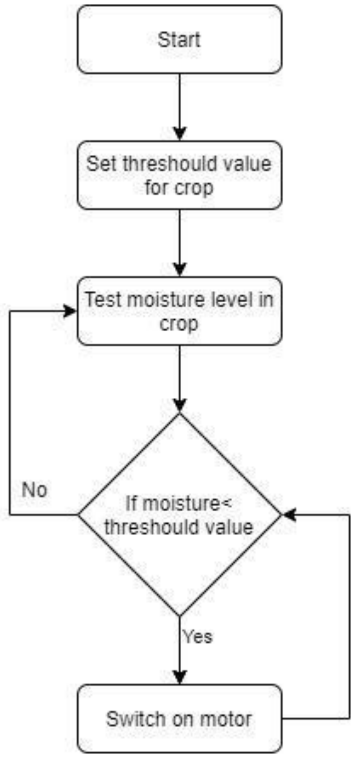

Fig 6 Flow-chart for automatic irrigation system

Case II: When the moisture level is lower than the threshold value.

If the moisture content reads from the soil using a SMS and is found to be less than the threshold value, the device bypasses one reading circle. A signal is sent to the engine to be informed of a change of condition. Valve for a specific strip with moisture content is lower than the maximum value is opened and the water flow from the pump is allowed toflow.

V. SYSTEM IMPLEMENTATION

Raspberry pi is connected to the sensors via analog to the digital converter, as the raspberry pi has only a digital GPIO port. Data analysis and decision-making process are programmed inside the raspberry pi. Processed Fertilizer data and irrigation specifications sent to a cloud database as well as a former's mobile phone through an android application. Control unit for reading the soil moisture of the crop. These collected values are then compared to the humidity level threshold values and therefore the motor is turned on or off, as shown in Fig 4. All real-time data made available on the Android application of a farmer's smart phone to monitor and control water management.

VI. CONCLUSION

India is the nation with the most agricultural land on its land. Irrigation required for agricultural output. The crop yield is higher and optimally irrigated. Determination of soil nutrients on a regular basis using manual testing in laboratories is difficult in the agricultural field. It causes ignorance on the part of farmers about the nutrient level in the soil and the excessive use of fertilizers at an inappropriate time. The proposed IoT system, which monitors the nutrients present in the soil and then alerts the farmer to the amount of fertilizer to be used during the cultivation of the soil in his farm. Automatic Water Management and Crop Monitoring for efficient irrigation through online automated intimation system using user-friendly Android app on farmers' electronic gadgets. This will be found to be of benefit to farmers in terms of high yields of crops and saving water resources.

VII. FUTURESCOPE

The soil sample for the experiment in our case would be for the cotton crop of the Vidarbha region only in the future this experiment can be carried out for other regions and other crops to prepare a database for the decision taking of the fertilizer requirement and an effective irrigation method. Agriculture automation can be combined with future agricultural systems. In the future, we can create an automated agricultural system that does not need any human interference, and crops can be cultivated and harvested without human intervention. In addition, crops grown using this method can grow much faster and become organic.

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